

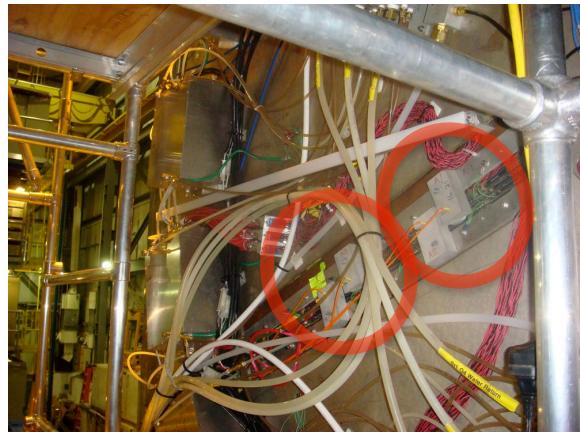
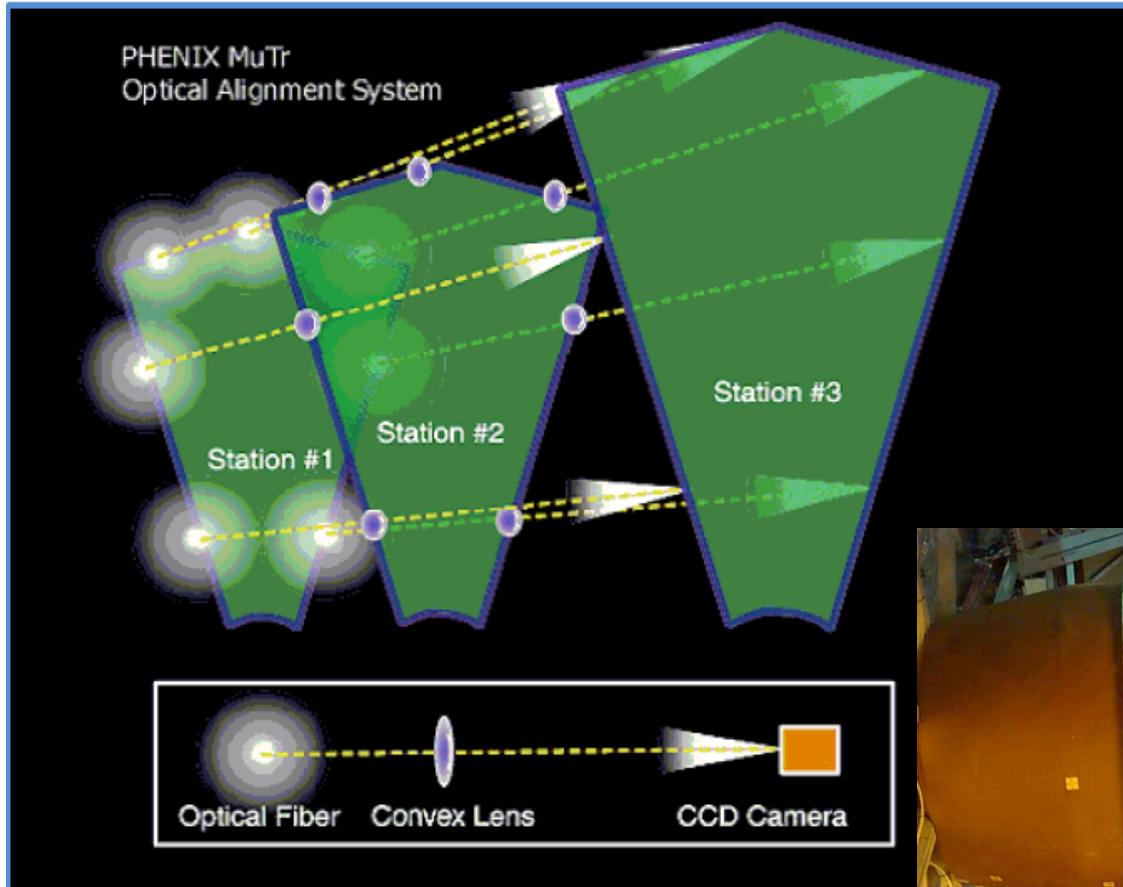
Optical Alignment System (OASys)

Masters Thesis of Yuki Ikeda
Rikkyo University

Presented by Itaru Nakagawa
RIKEN/RBRC

OASys

7 light source – lens – camera sets per octant

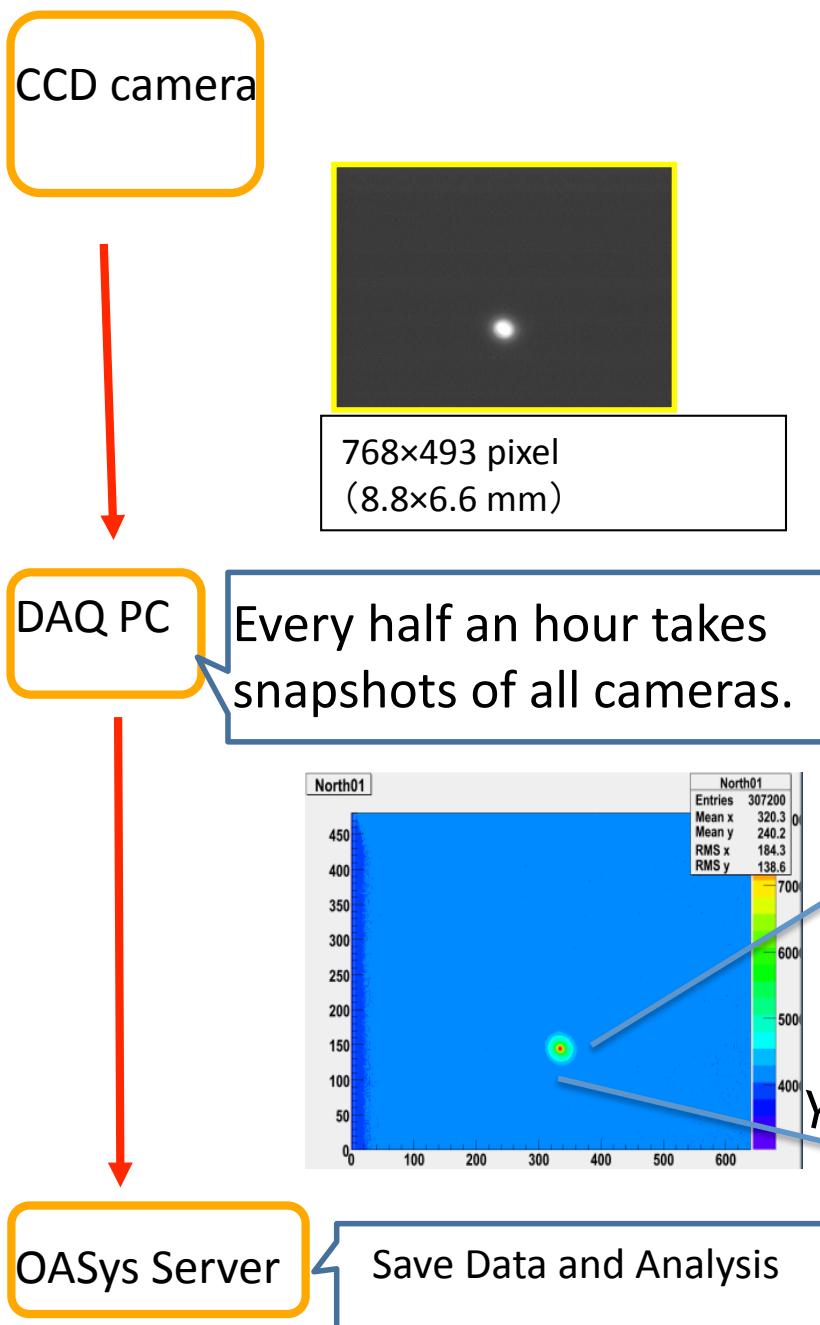


St-1 Light source



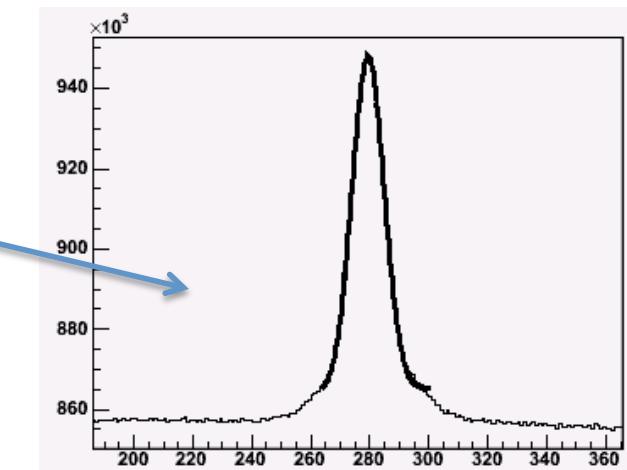
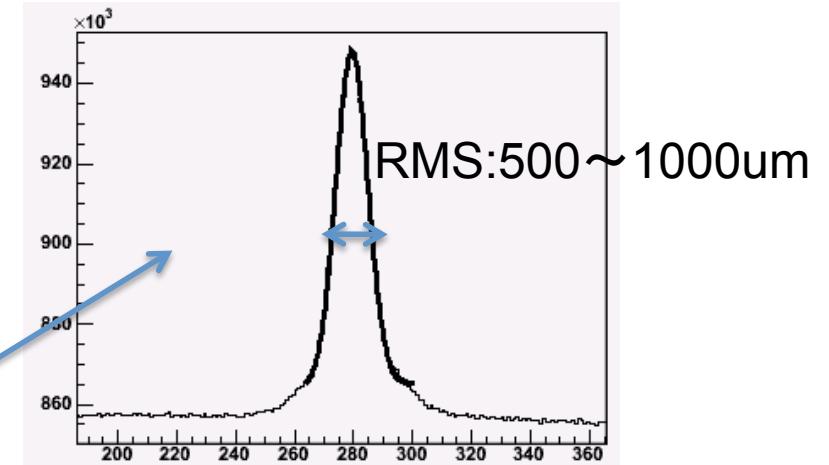
St-3 CCD Cameras

DAQ and Raw Level Analysis



X-projection

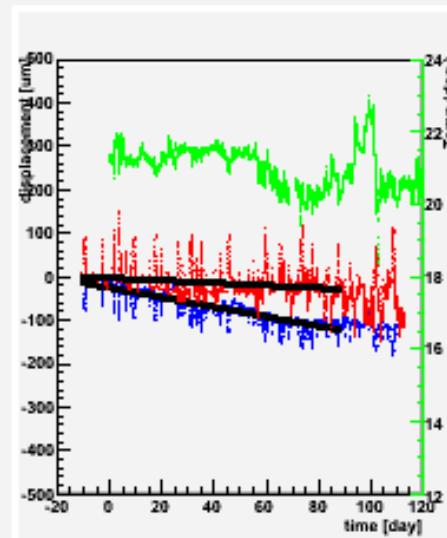
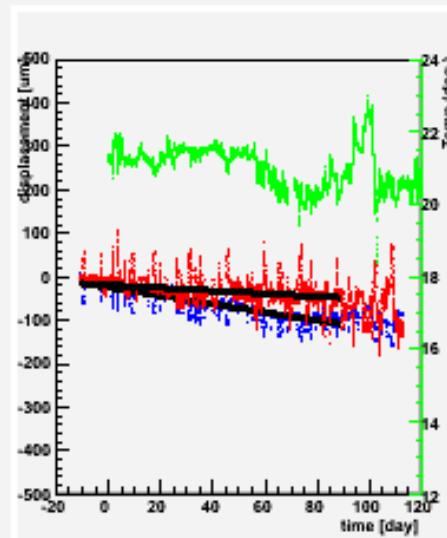
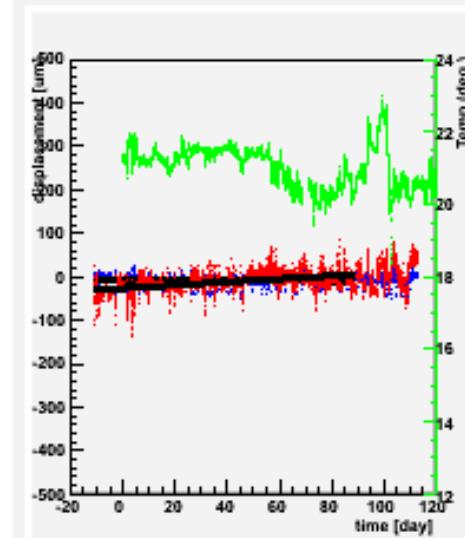
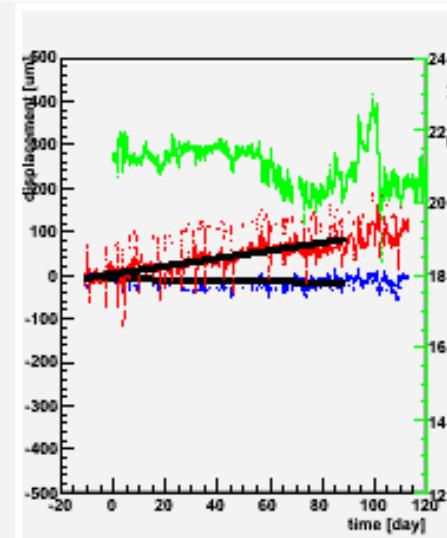
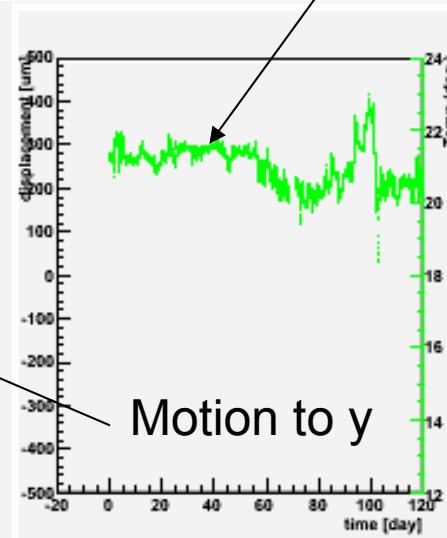
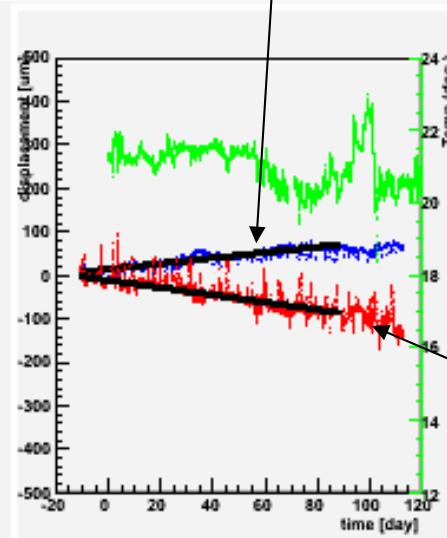
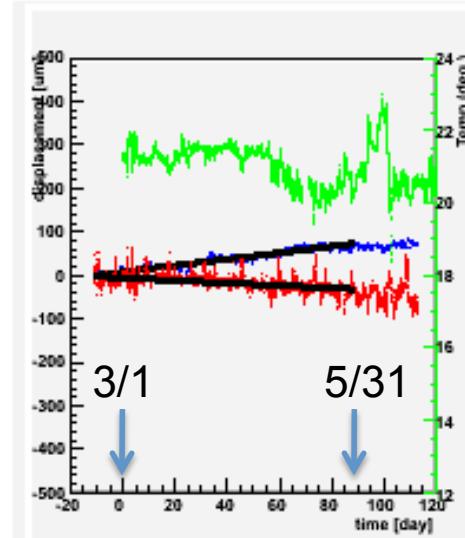
Y-projection



OASys Monitoring Thru Run09

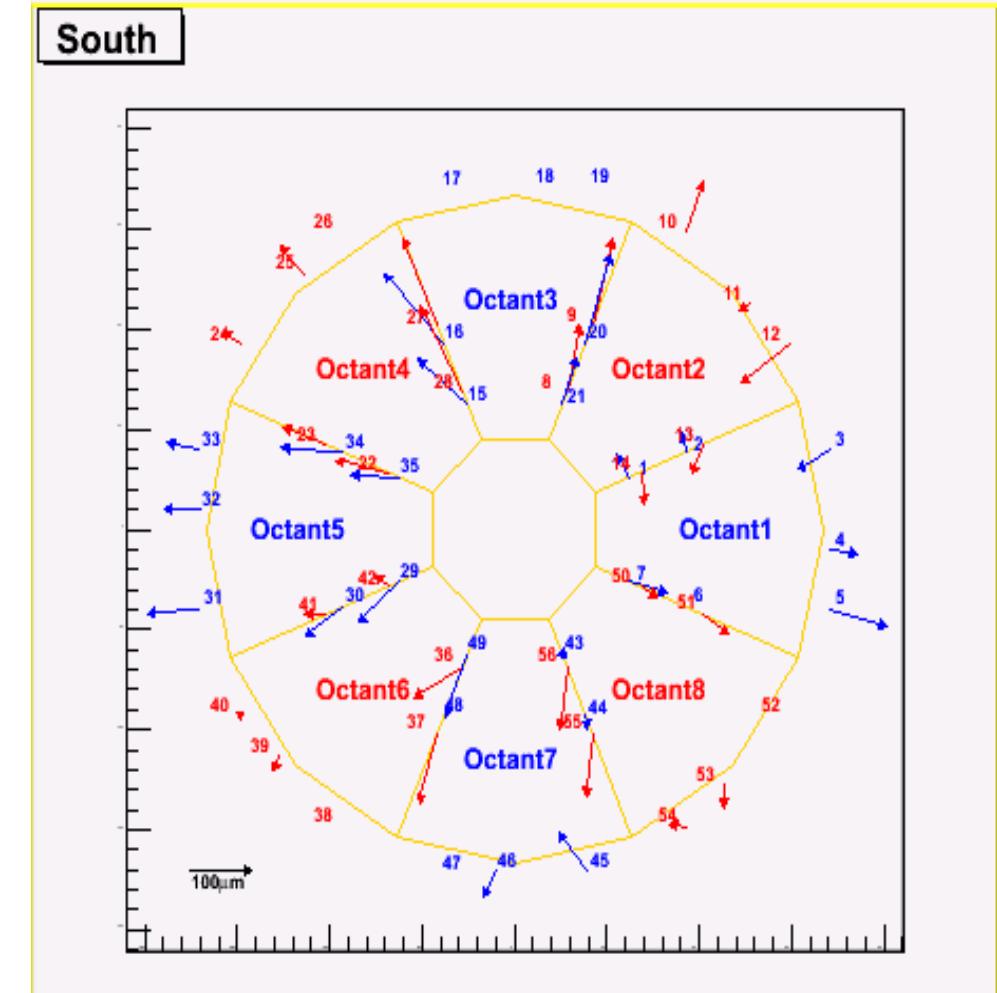
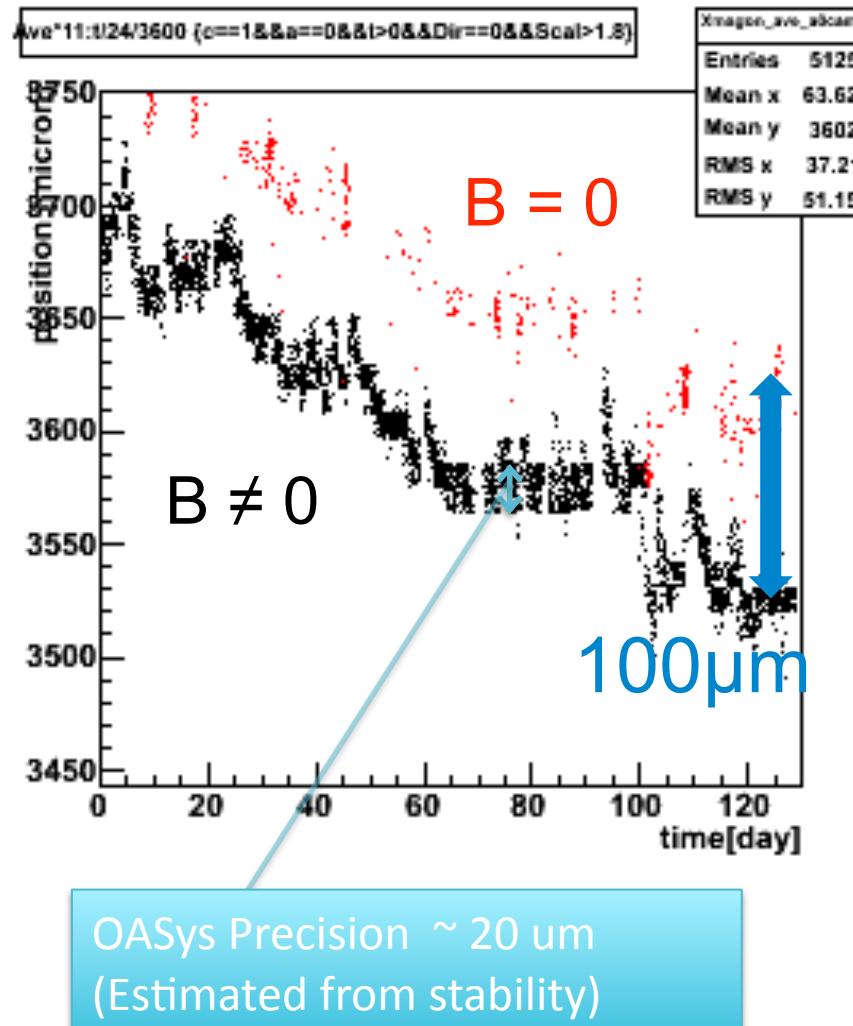
Motion to x

IR Temperature



Chamber Motion Due to Magnet On/Off

Typical Motion

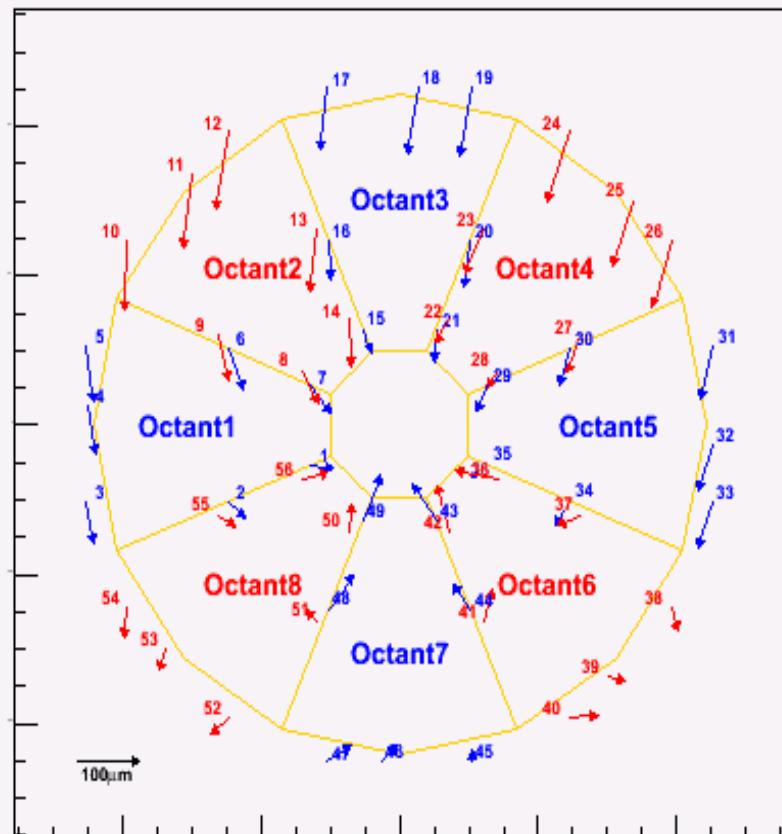


Indeed Chamber Moves ~ 100um, but to Radial Direction

No Need for Alignment Correction. MuTr doesn't have resolution to radial anyway.

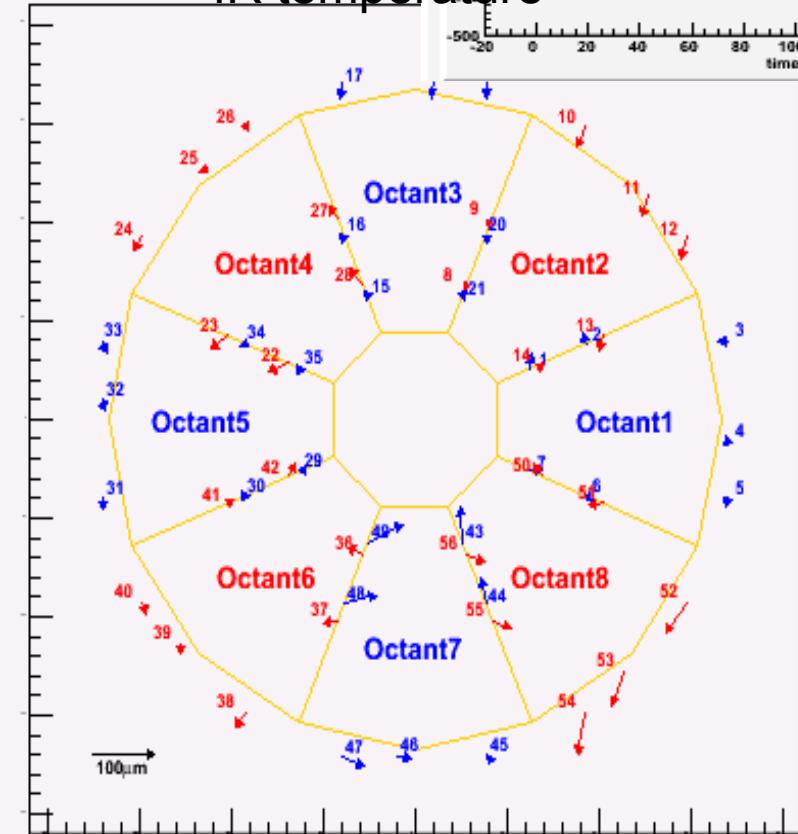
Correlation w/ Temperature

North

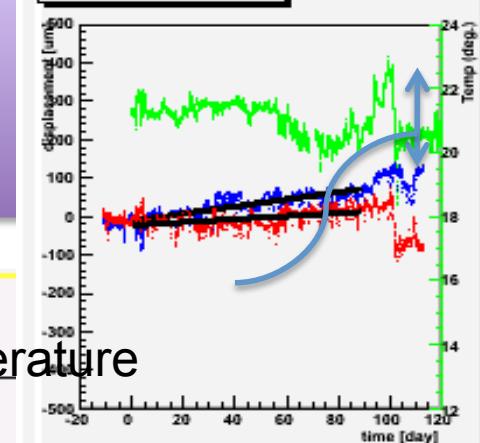


South

IR temperature



North_octant4_camera1



Material

G10

duralumin

Expansion/(m/ $^{\circ}$ C)

9×10^{-6}

21×10^{-6}

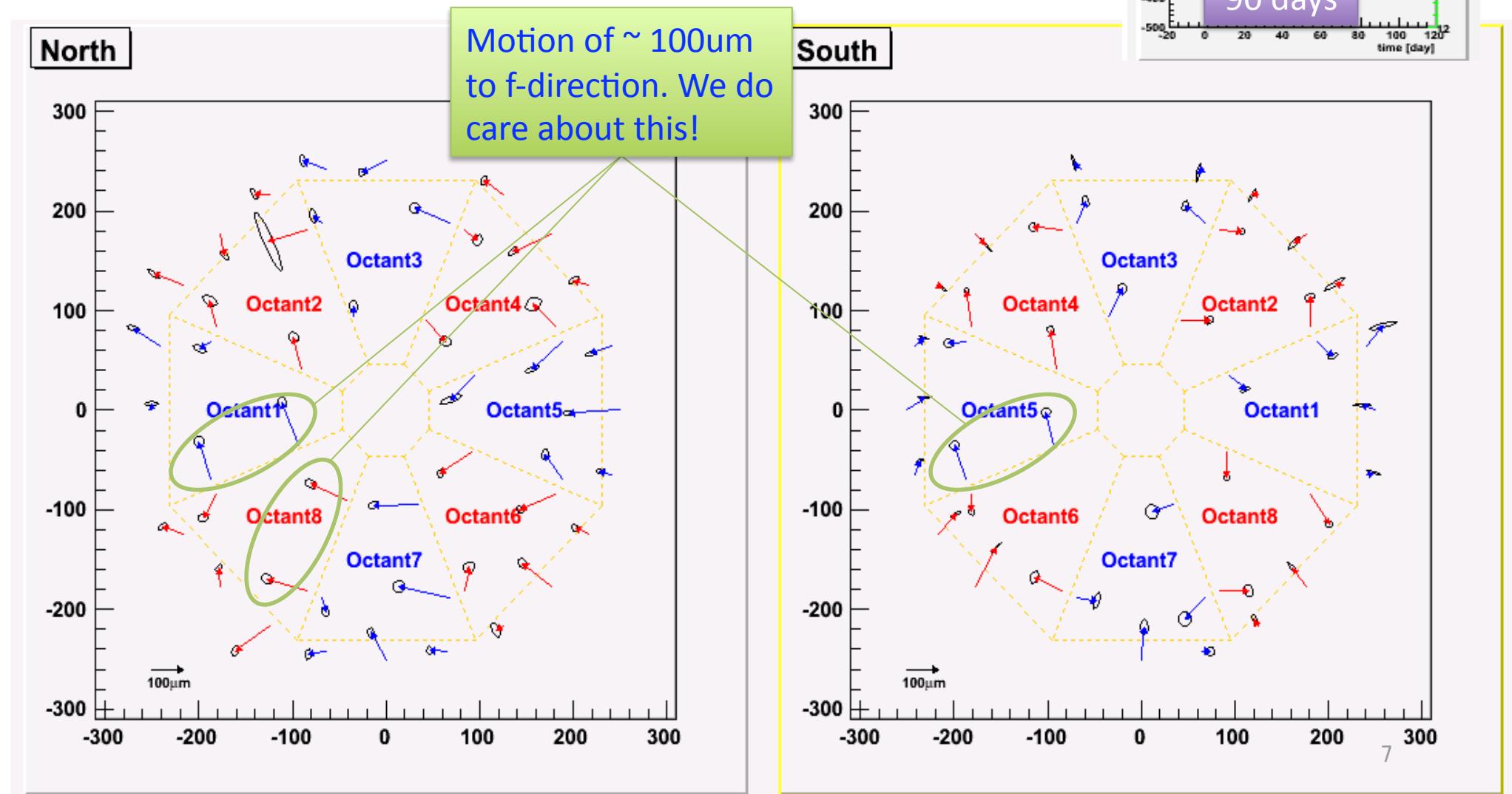
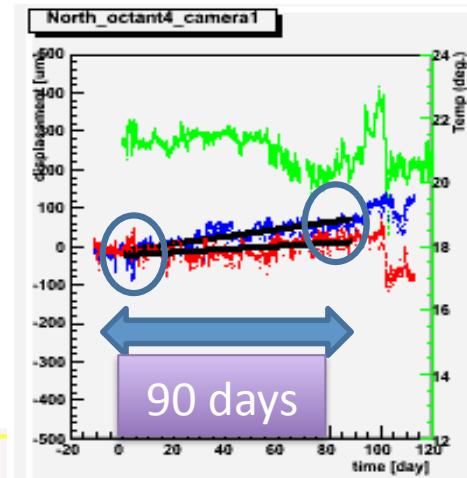
Expansion/(2m/ 2° C)

20 μm

40 μm

Long Term Motion : ~ 90 Days

Took sample from March 1st ~ May 31
Approximately linear drift motions were observed in all cameras.

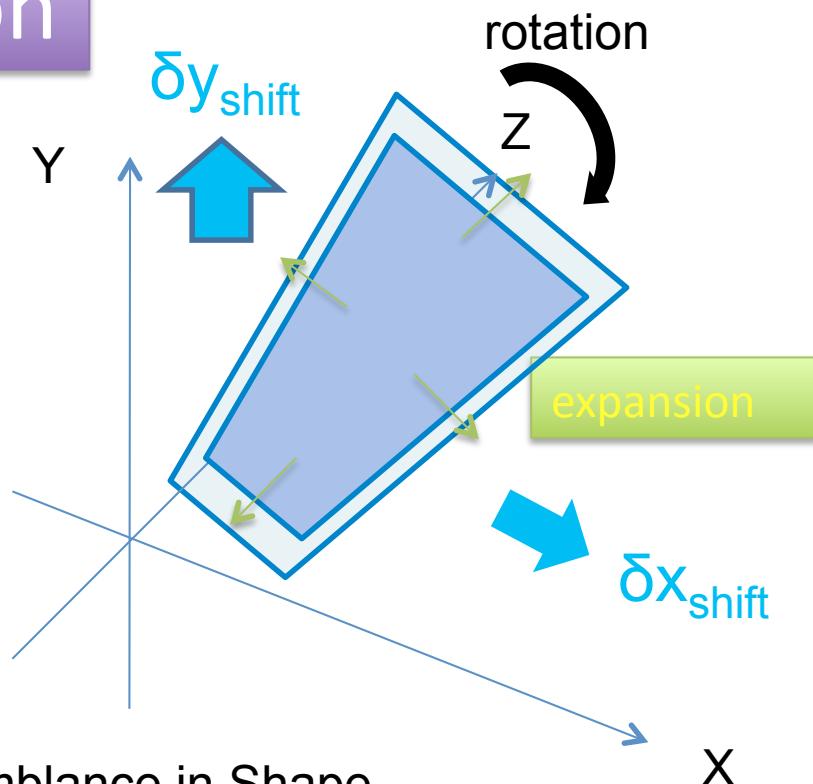


Modeling Chamber Motion

Introduced

1. Shift : x and y
2. Rotation (around beam pipe)
3. Expansion

$$\begin{pmatrix} \delta x_{\text{total}} \\ \delta y_{\text{total}} \end{pmatrix} = \begin{pmatrix} \delta x_{\text{shift}} \\ \delta y_{\text{shift}} \end{pmatrix} + \begin{pmatrix} \delta x_{\text{rotation}} \\ \delta y_{\text{rotation}} \end{pmatrix} + \begin{pmatrix} \delta x_{\text{expansion}} \\ \delta y_{\text{expansion}} \end{pmatrix}$$



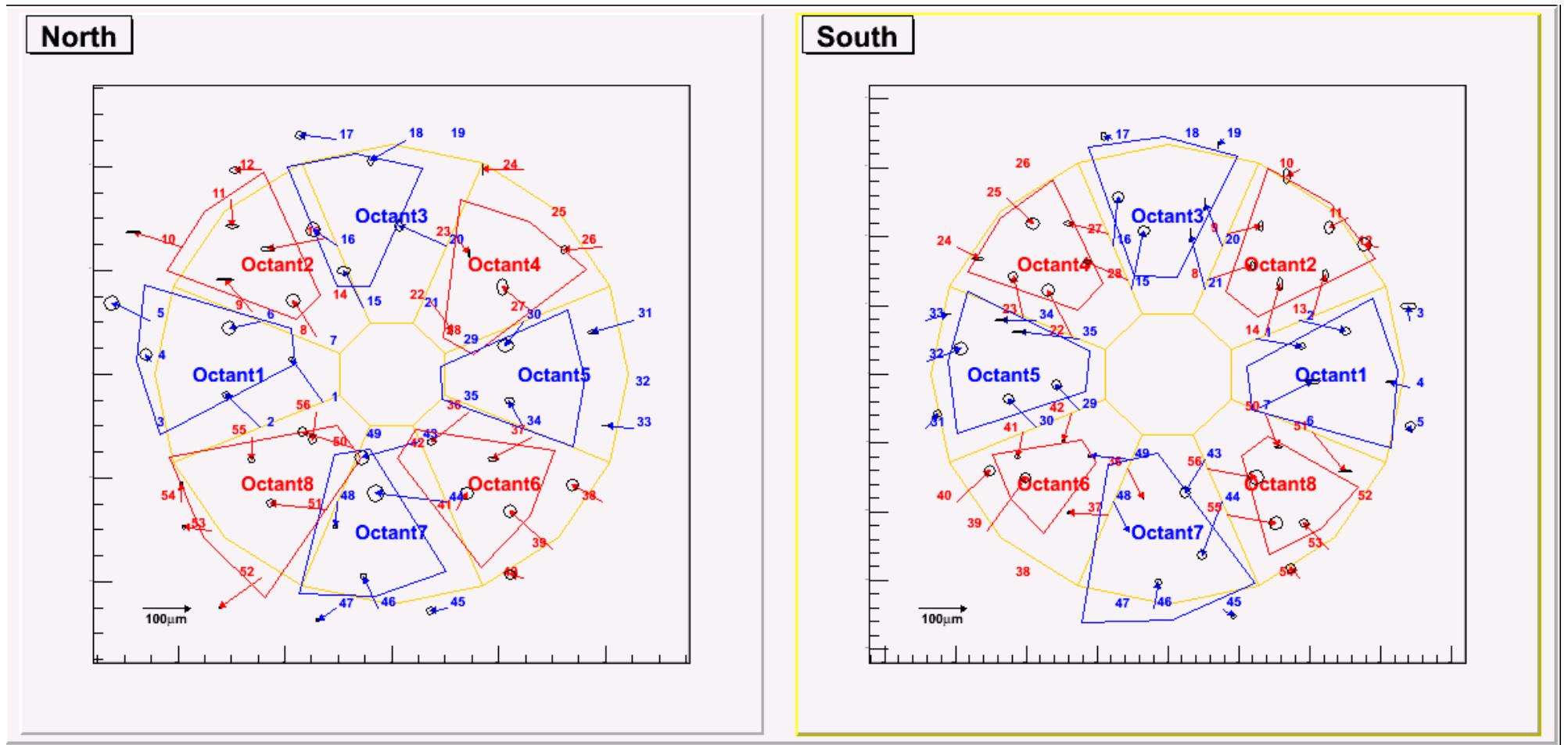
Assuming Resemblance in Shape
no twist, no dent, no bent ...

$$\begin{pmatrix} \delta x_{\text{total}} \\ \delta y_{\text{total}} \end{pmatrix} = \begin{pmatrix} \delta x_{\text{shift}} \\ \delta y_{\text{shift}} \end{pmatrix} + \theta_{\text{rotation}} \begin{pmatrix} x \\ y \end{pmatrix} + \alpha_{\text{expansion}} \begin{pmatrix} x \\ y \end{pmatrix}$$



4 free parameters out of 7 cameras × 2 (x,y) = 14 data points

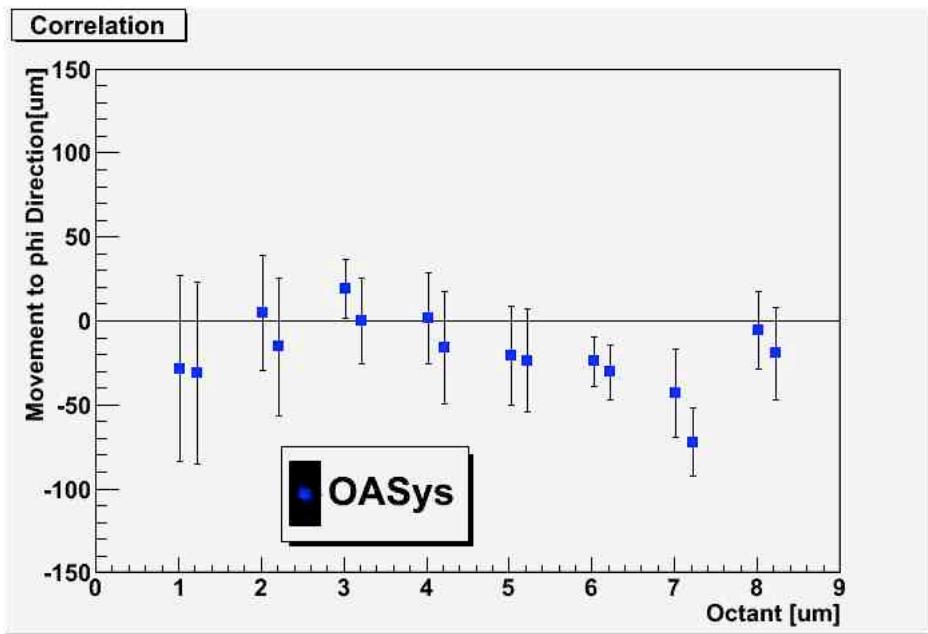
Result of Model Fit



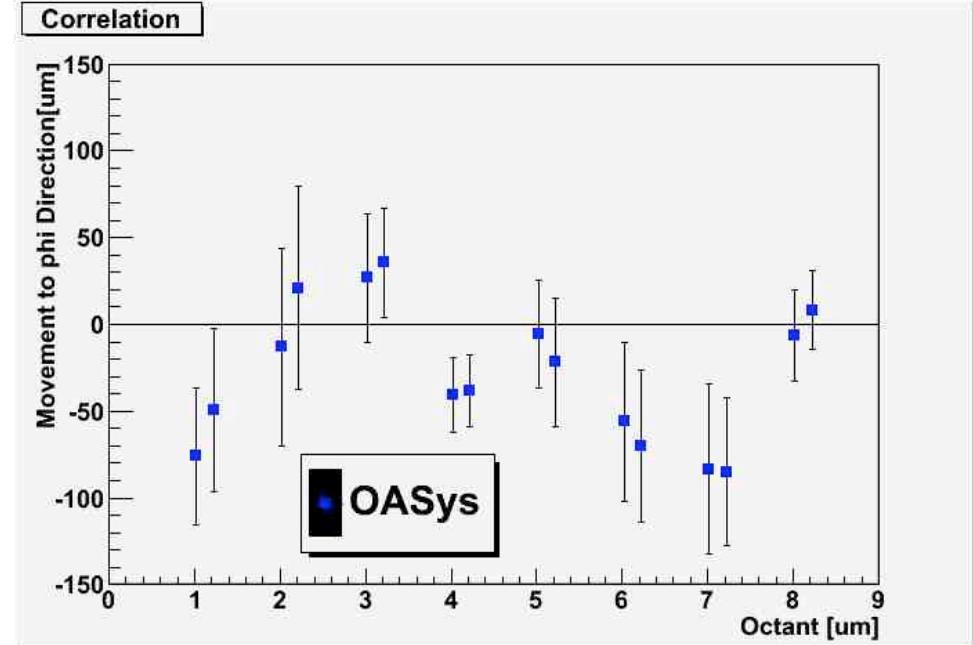
$$9 < \chi^2/\text{d.o.f} < 50$$

No Common Motion Between Octants. Seems Independent.

Motion to ϕ -Direction



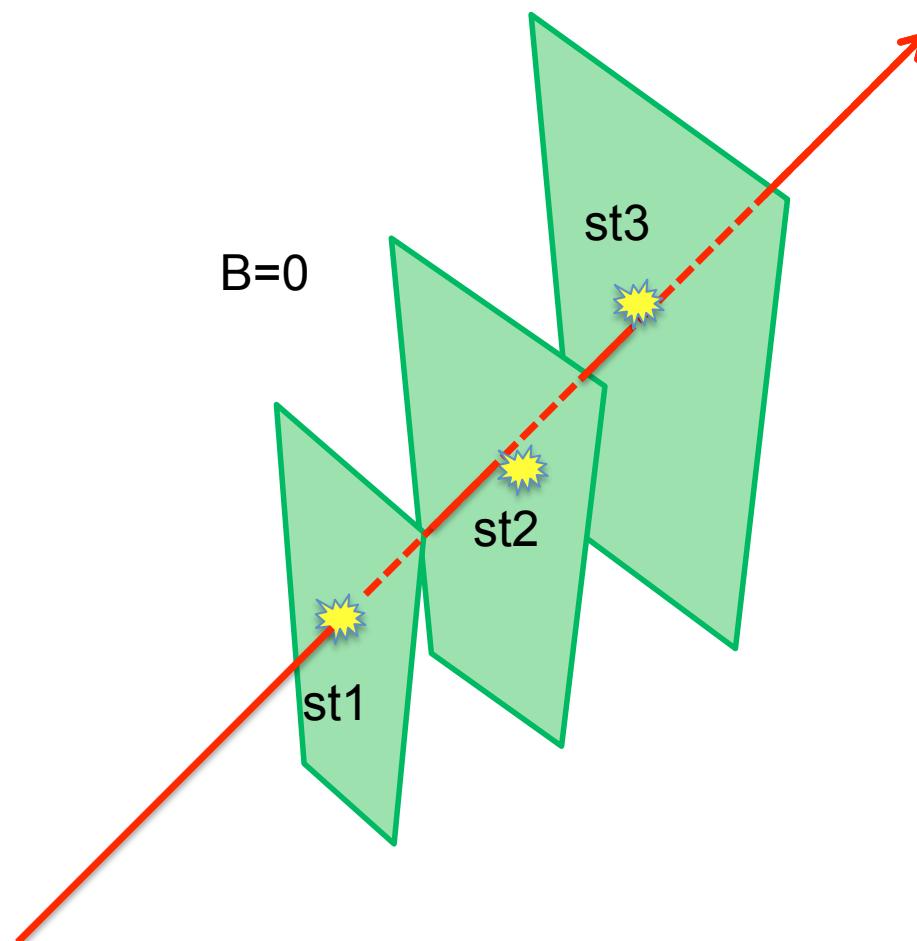
South



North

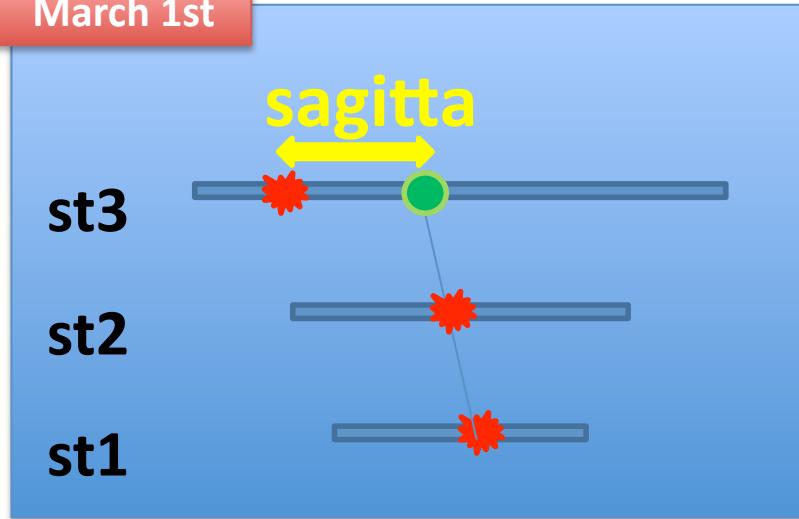
Consistency Check w/ Zero Field Run

- Independent Alignment Measurement

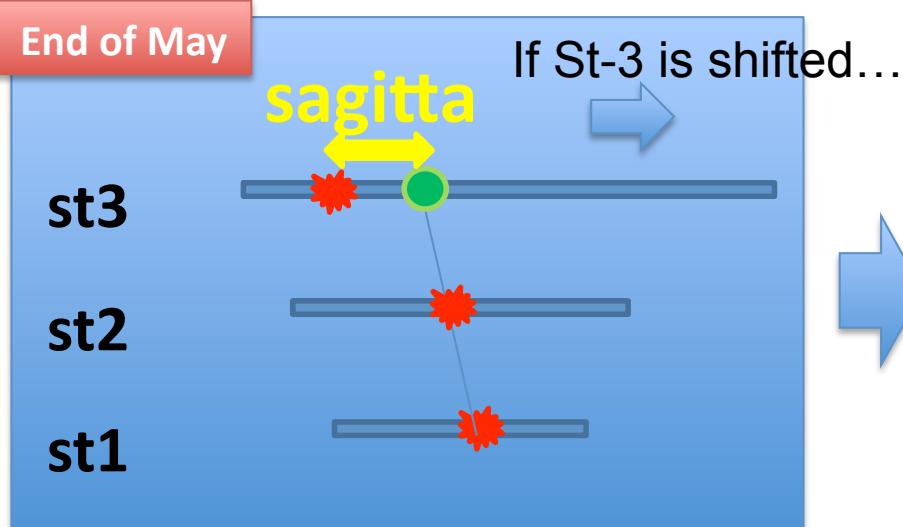


Zero Field Sagitta Distribution

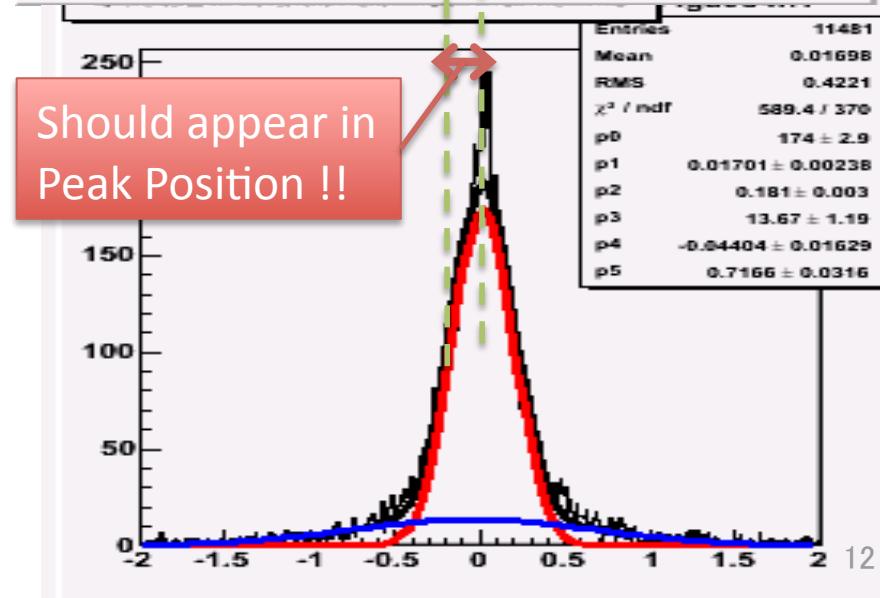
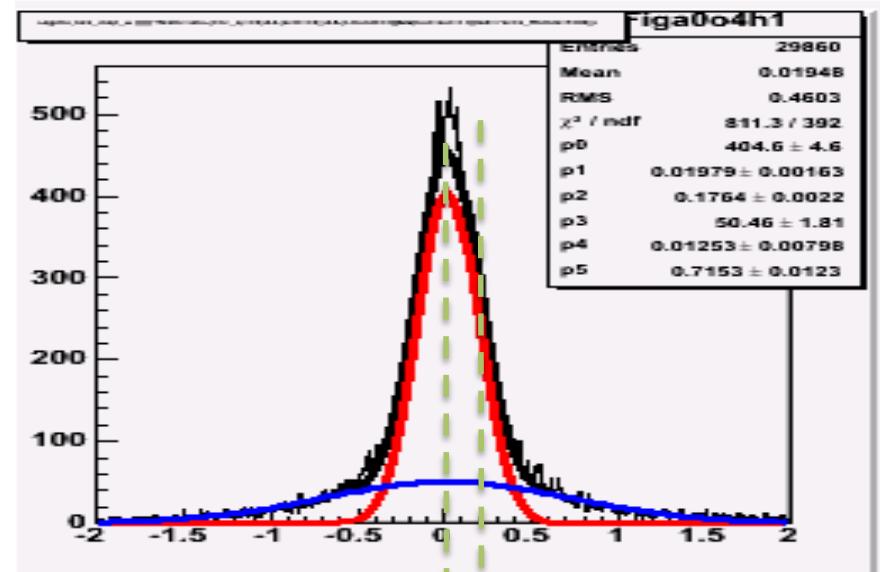
March 1st



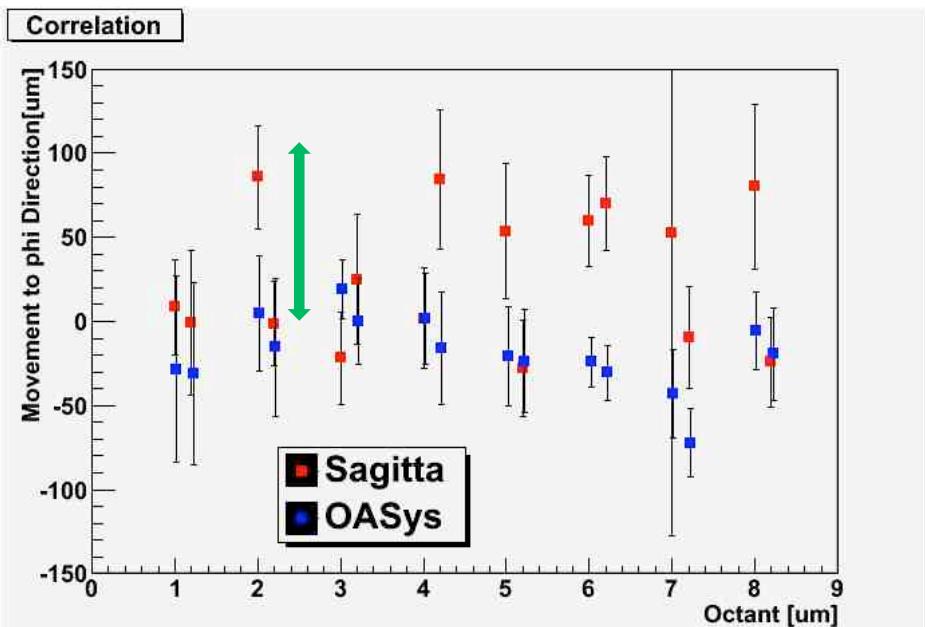
End of May



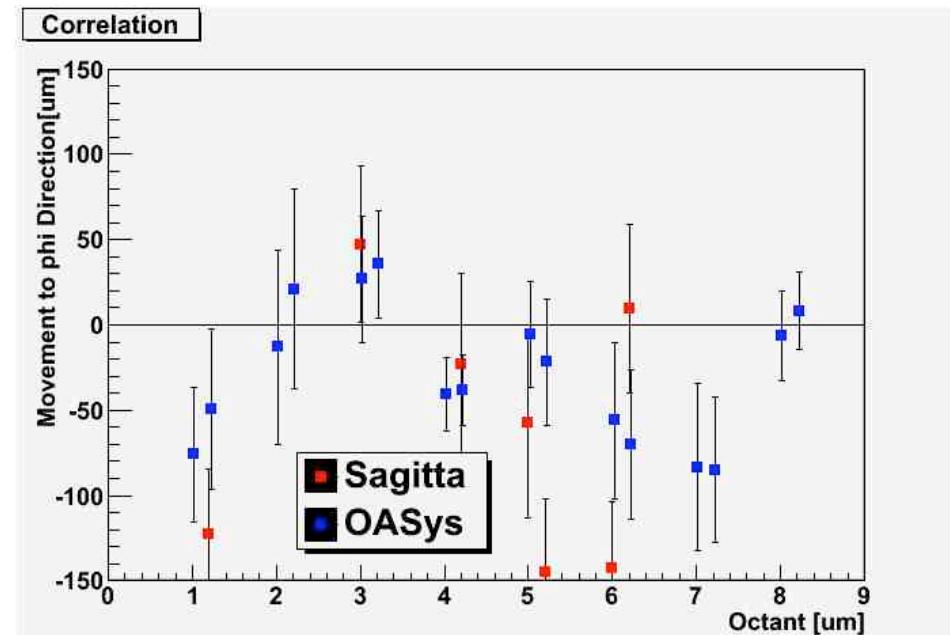
Sagitta Distribution



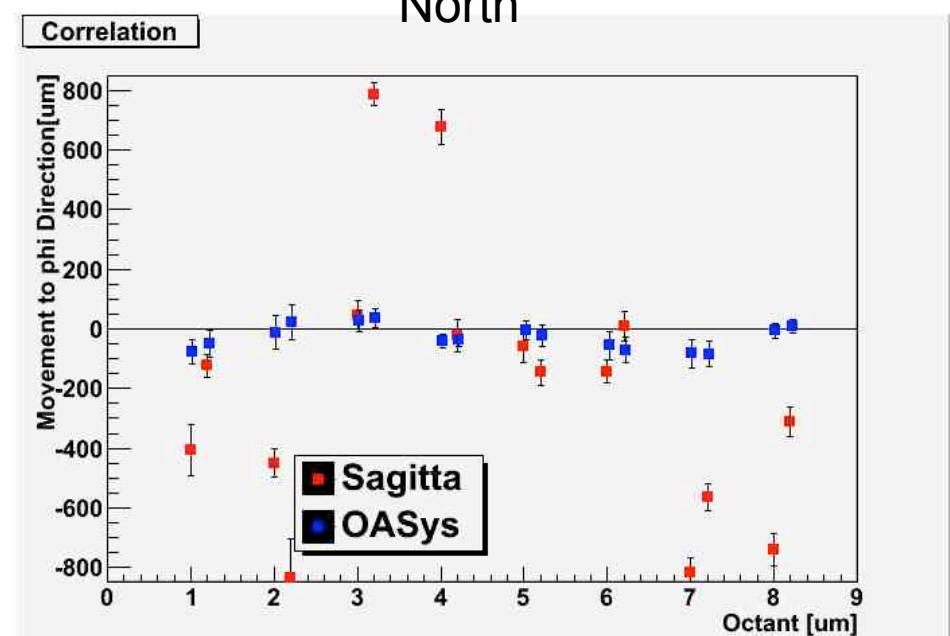
OASys .vs Sagitta Comparision



South



North



Issues

- OASys Side :
 1. Chamber motion seems to be complicated. Need more degree of freedom to models.
 2. There are conflicting vectors indicated by adjacent cameras. Within the present estimation of stability error, they can't be explained. Not yet known if this is real or software or hardware issue.
- Sagitta Side:
 1. Relevant event selection couldn't applied, due to statistical limit to locate peak position within $<30\mu\text{m}$.
 2. Concluded relevant comparison cannot be done with OASys and simple shift of sagitta peak position from Run9 data set.
 3. Need to Compare with "Millepede" (Resolve Inverse Matrix of zero field track) Analysis between B=0 data of 3/1 and 5/31.

Future Plans

- OASys and B=0 data Consistency needs to be confirmed.
- OASys will be a monitor of Chamber alignment during run.
- Full automation of analysis $\Delta\phi$ will warn shift crews $\Delta\phi > 100\mu\text{m}$ from reference point. Take zero field data!!